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DOCUMENT-IDENTIFIER: US 6614923 B1
TITLE: Pattern inspecting method and apparatus thereof, and pattern inspecting method on basis of electron beam images and apparatus thereof

Abstract Text (1):
For purpose of providing a defect inspecting method and an apparatus thereof and a defect inspecting method on basis of electron beam image and an apparatus thereof, reducing possibility of bringing erroneous or false reports due to the test objection side and the inspecting apparatus side, being caused by discrepancies, such as the minute difference in pattern shapes, the difference in gradation values, the distortion or deformation of the patterns, the position shift, thereby enabling the detection of the defects or the defective candidates in more details, wherein an image which is small in distortion by controlling the electron beam scanning is detected and divided into a size so as to be able to neglect therefrom, and then position shift detection and defect decision are carried out in an accuracy less or finer than pixel for each division unit. In the defect decision, a desired tolerance can be set up depending upon changes in gradation values and the position shift.

Application Filing Date (1):
19990106

Brief Summary Text (4):
In a conventional art 1, as is described in Japanese Patent Laying-Open No. Sho 57-196377 (1982), there is already know a testing or an inspection, wherein a pattern including a repetitive pattern, being formed on an object to be tested or inspected such as a semiconductor wafer, is detected to be memorized, and the detected pattern is fitted or aligned with to a pattern which is memorized one time before, in an accuracy of degree of each pixel, thereby extracting a discrepancy or difference between the two patterns fitted or aligned with in the positions thereof so as to recognize or acknowledge the defects therein. Further, in a conventional art 2, as is disclosed in Japanese Patent Laying-Open No. Hei 3-177040 (1991), there is also known a technology, wherein a portion due to distortion or deformation in the detection points or positions between two pictures is improved among the problems of discrepancies or differences between the both images in normal portions thereof. Namely, in the conventional art 2, there is described the technology, wherein an object pattern is detected as a picture signal, and the detected pattern is aligned, or adjusted in the position by an unit of pixel with that which is memorized in advance or that which is detected separately. The two of them, which are aligned in positions by the unit of pixel (pixel unit), are further aligned in positions at a degree being finer or lower than the pixel (i.e., sub-pixel unit), so as to be compared and extracted errors therefrom in the image signals of those two patterns which are aligned in positions at the degree finer than the pixel, thereby recognizing or acknowledging the defect(s) of the pattern (s).

Brief Summary Text (5):
Between the two pictures to be compared, there exist the minute difference in the pattern shape, the differences in the values of gradation, distortion or deformation in the patterns, misalignment in positions and so on, even in a normal

portion, due to a detection object sample itself and an image detection system thereof. Namely, as the discrepancies or inconsistency in the normal portion, there are some which are caused by the object itself and other(s) which are caused by a side of the testing or inspecting apparatus thereof.

Brief Summary Text (6):
The discrepancy or inconsistency caused by the test object is mainly due to a delicate difference caused through a wafer fabricating processes, such as etching and so on. This is because it looks to be the minute difference in shapes, or as the gray level difference between the repetitive patterns on the detected images.

Brief Summary Text (7):
The discrepancies, which are caused at the testing or inspecting apparatus side, include quantizing errors due to vibration of stages, various electric noises, mis- or mal- focusing and sampling, fluctuation in illumination light amount especially in a case of an optical system, fluctuation in electron beam current especially in a case of an electron beam system, and gaps or shifts in scanning position of the electron beam due to electrical charge of the sample and/or of an electronic-optical system, etc. In particular, in the electron beam system, influences due to geometric distortion is remarkable in the periphery portion of the test object. Those appear in the forms of differences in the gradation values of the portion of the image, the geometric distortion, and the gaps or shifts in the position.

Brief Summary Text (9):
Further, with the conventional art 2 mentioned above, though an only effect can be obtained in reducing or lowering the influence due to the misalignment in the positions between the pictures or images, among those influences due to the minute difference in the pattern shape, the differences in the gradation values, the distortion or deformation of the patterns, and the gaps or shifts in positions and so on, which are caused by the test object itself and the image detecting system thereof, but it is still not sufficient, nor takes the other problems into considerations thereof any more.

Brief Summary Text (11):
An object is, according to the present invention for dissolving the problems of the conventional arts mentioned above, to provide a pattern testing method and an apparatus therefor, which can further reduce or lower the possibility of occurring the erroneous reports which are caused by the discrepancies or differences due to the sample itself and the image detecting system thereof, so as to enable the detection of the more minute or the finer defects.

Brief Summary Text (17):
Namely, according to the present invention, there are provided an image dividing and cutting-out step or means thereof, for memorizing said first image data and second image data sequentially for a predetermined area, and for dividing and cutting out each of those first and second data memorized sequentially into such a small area unit to be able to neglect such as the distortion therein; and a deciding step or means thereof, for comparing the first divided image and the second divided image, which are divided in the image dividing and cutting-out step or means thereof for the each division unit so as to calculate difference of the both images, and for deciding the defect or the defective candidate upon the basis of the difference between the both images, which are calculated for the each division unit.

Brief Summary Text (19):
Further, according to the present invention, there are provided a position shift detecting step or means thereof, for detecting the position shift quantity between the first divided image and the second divided image, which are divided and cut out in said image dividing and cutting-out step or means thereof for the each division unit, and a deciding step or means thereof, for deciding to be the defect or the

defective candidate, by comparing the first divided image and the second divided image, which are divided in the image dividing and cutting-out step or means thereof for the each division unit, so as to calculate the difference in the gradation values between the both images, and by basing upon a reference value for decision of containing fluctuating component in the gradation values which can be calculated out depending on the position shift quantity detected in the position shift detecting step or means thereof, with respect to the difference between the both images in the gradation values calculated for the each division unit.

Brief Summary Text (20):
Further, according to the present invention, there are provided a position shift detecting step or means thereof, for detecting the position shift quantity between the first divided image and the second divided image, which are divided and cut out in said image dividing and cutting-out step or means thereof for the each division unit; and a deciding step or means thereof, for deciding to be the defect or the defective candidate, by comparing the first divided image and the second divided image, which are divided in the image dividing and cutting-out step or means thereof for the each division unit, so as to calculate the difference between the both images depending upon the position shift quantity detected for the each division unit by the position shift detecting step or means thereof, and by basing upon the difference between the both images calculated for the each division unit.

Brief Summary Text (21):
Further, according to the present invention, there are provided a position shift detecting step or means thereof, for detecting the position shift quantity between the first divided image and the second divided image, which are divided and cut out in said image dividing and cutting-out step or means thereof for the each division unit; and a deciding step or means thereof, for deciding to be the defect or the defective candidate, by comparing the first divided image and the second divided image, which are divided in the image dividing and cutting-out step or means thereof for the each division unit, so as to treat the position shift compensation depending upon the position shift quantity detected for the each division unit by the position shift detecting step or means thereof, by calculating the difference between the first divided image and the second divided image on which the position shift compensation is treated, and basing upon the difference between the both images calculated for the each division unit.

Brief Summary Text (25):
As mentioned in the above, according to the above constructions, in the inspection of patterns formed on the sample with use of the electron microscope, it is possible to reduce the possibility of bringing about erroneous or false reports due to the sample side and the inspecting apparatus side thereof, which are caused by discrepancies, such as the minute difference in pattern shapes, the difference in the gradation values, the distortion or deformation of the patterns, the position shifts, thereby enabling the detection of the defects or the defective candidates in more details. In particular, it is possible to deal with the dynamic image distortion.

Drawing Description Text (12):
FIG. 11 shows a view for explaining meaning of the position shift of sub-pixel unit;

Detailed Description Text (36):
In the position shift detection portion 44a for the division unit, on the first portions f1a(x, y) and g1a(x, y) of the image which are read out by a first division unit from the respective two-dimension image memories 42a an d 42b with the designation on the basis of the coordinates for the each division unit from the total controller portion 104, position alignment is performed by an unit of the pixel within pixel unit position aligning portions 441 and 447 so as to output f2a (x, y) and g2a(x, y), or f4a(x, y) and g4a(x, y). Thereafter, in the position shift

detector portion 442 for detecting the position shift quantity finer than the pixel unit (i.e., sub-pixel unit), a position shift amount or quantity .delta.xOa in the x direction and position shift amount or quantity .delta.yOa in the y direction, i.e., a position shift amount or quantity between f2a(x, y) and g2a(x, y) or that between f4a(x, y) and g4a(x, y) is obtained in an accuracy of the sub-pixel. Similarly, in the position shift detector portion 44b for a second division unit area, on the second portions f1b(x, y) and g1b(x, y) of the picture, which are read out by the second division unit from the respective two-dimension image memories 42a and 42b with the designation on the basis of the coordinates for each division unit from the total controller portion 104, the position alignment is performed by an unit of the pixel in the pixel-unit position aligning portion 441 so as to output f2b(x, y) and g2b(x, y) or f4a(x, y) and g4a(x, y). Thereafter, in the position shift detector portion 442 for detecting the shift in the sub-pixel unit, the position shift quantity .delta.xOb between f2b(x, y) and g2b(x, y) or .delta.yOb between f4b(x, y) and g4b(x, y) is also obtained in the accuracy of sub-pixel unit. In the position shift detector portions 44c and 44d for a third division unit area and for a fourth division unit, similarly, on the third portions f1c(x, y) and g1c(x, y) of the image and the fourth portions f1d(x, y) and g1d(x, y) thereof, which are read out by the third division unit and the fourth division unit from the respective the two-dimension image memories 42a and 42b with the designation on the basis of the coordinates for each division unit from the total controller portion 104, the position alignments are performed by the pixel unit in the pixel unit position aligning portions 441 so as to output f2c(x, y) and g2c(x, y), f4c(x, y) and g4c(x, y) and f2d(x, y) and g2d(x, y), or f4d(x, y) and g4d(x, y). Thereafter, in the position shift detector portion 442 for detecting the shift in the sub-pixel unit, the position shift quantity 6xOc between f2c(x, y) and g2c (x, y) or byOd between f4d(x, y) and g4d(x, y) is obtained in the accuracy of the sub-pixel unit positional relationships of f1a(x, y), f1b(x, y), f1c(x, y) and f1d (x, y) on continuous data are shown in FIG. 8 in the coordinates by the division units, which the total controller portion 104 sets up and designates into the image memory 42a. A reason for overlapping the division units each other in the areas thereof which the total controller portion 104 sets up and designates onto the picture memory 42a, is for avoiding possibility of occurring the region or area which cannot be tested due to the position shift. An amount of the overlapping is necessitated to be more than a maximum value which can be estimated. The position relationships of g1a(x, y), g1b(x, y), g1c(x, y) and g1d(x, y) on the continuous data in the coordinates which the total controller portion 104 sets up and designates into the picture memory 42b, is also similar to the above. In the position shift detector portions 44a-44d for the respective division unit areas (i.e. division unit), as shown in FIG. 10, when the process of position alignment by the division unit is completed, for example, with respect to the image which is read out from each of the memories 42a and 42b by the division unit being indicated with a solid line in FIG. 8, then a process for position alignment is initiated between the images of the division units f2a(x, y), f2b(x, y), f2c(x, y), f2d(x, y), and images g2a(x, y), g2b(x, y), g2c(x, y), g2d(x, y) which are indicated by broken lines. Namely, in FIG. 10(a) is shown the contents of the process by the each division unit which is indicated by the solid line, and in FIG. 10(b) is shown the contents of the process by the each division unit which is indicated by the broken line. The images are detected continuously one by one, therefore, the division unit indicted by the broken line is executed with the process which was executed one step before by the division unit which is indicated by the solid line (i.e., a pipe-line process).

Detailed Description Text (37):
Namely, in the time of "(1) process at 441" on the area of the division unit indicated by the solid line, the read-out of the division unit indicated by the broken line is done from the image memories 42a and 42b. Then, in the time of "(2) process at 442 & writing into memories 45a, 45b" on the division unit indicated by the solid line, the "(1) process at 441" is carried out on the division unit indicated by the broken line. Then, in the time of "(3) processes at 461, 462" on

the division unit indicated by the solid line, the "(2) process at 442 & writing into memories 45a, 45b" is done on the division unit indicated by the broken line. Then, in the time of "(4) process at 463", on the division unit indicated by the solid line, the "(3) processes at 461, 462" on the division unit indicated by the broken line is done. On a while, as shown in FIG. 8, for avoiding the region or area which cannot be tested or inspected, the read-out with the overlapping in the y direction is also necessitated from the image memories 42a and 42b. However, between the variations of the first embodiment which will be shown in FIGS. 13, 15, 17, 18 and 20, there can be a difference more or less in the explanation in the above.

Detailed Description Text (41):
The above .SIGMA..SIGMA..vertline.f1-g1.vertline. means the sum of absolute values of the differences between the detected image f0(x, y) and the comparison or reference image g1(x, y) in the image of all over the division unit areas. While, the .SIGMA..SIGMA.(f1-g1).sup.2 means the value integrated in the x direction and the y direction all over the respective division unit areas, by multiplying the difference between the detected image f0(x, y) and the comparison image g1(x, y) by itself. Or, alternatively, a well-known mutual correlation between f1 and g1 can also be applied thereto. Here, an explanation will be given in a case where the .SIGMA..SIGMA..vertline.f1-g1.vertline. is adopted.

Detailed Description Text (45):
In the position shift detector portion 442 for each division unit area, detecting it in the sub-pixel unit, the position shift quantity less than the pixel is calculated over the division unit area (the position shift quantity comes to be a real number between 0 and 1). The position shift quantity over the division unit area is a condition as shown in FIG. 11. In FIG. 11, a squire indicated by a chained line is the pixel, and it is a unit that is detected by an electron detector 35 and to be converted into a digital value by sampling with the A/D converter 39.

Detailed Description Text (46):
In the same figure, the comparison image g2 for each division unit area (over the division unit) is shifted in the position, by only 2*.delta.x in the x direction and 2*.delta.y in the y direction, with respect to the detected image f2 (over the division unit areas). For measuring the degree of adjustment, there is also a choice as indicated by the equation (Eq.4), however, here is shown an example where the "sum of squires of the differences" (i.e., .SIGMA..SIGMA.(f1-g1).sup.2) is applied to.

Detailed Description Text (47):
Now, it is assumed that the position shift amount or quantity at a central position of the detected image f2(x, y) for the each division unit and the comparison image g2(x, y) for the each division unit is zero (0). Namely, under the condition shown in FIG. 11, it is assumed that f2 is shifted only by -.delta.x in the x direction and by -.delta.y in the y direction, and g2 is shifted only by +.delta.x in the x direction and by +.delta.y in the y direction. Since .delta.x and by are not the integers, there is a necessity of defining the value between the pixel and the pixel for shifting it only by .delta.x and .delta.y. The detected image f3 for the each division unit area, which is shifted by +.delta.x in the x direction and by +.delta.y in the y direction, and the comparison image g3, which is shifted by -.delta.x in the x direction and by -.delta.by in the y direction, are defined by the following equations (Eq.7) and (Eq.8).

Detailed Description Text (48):
The equations (Eq.7) and (Eq.8) are so-called the linear compensations. The degree of adjustment or compensation e2(.delta.x,.delta.y) between f3 and g3 comes to be indicated by the following equation (Eq.9) when applying the "sum of squires of the differences".

Detailed Description Text (54):
Following to the above, a defect determining portion 64 for each one set of division units within defect determining portions 64a-64d for each division unit shown in FIG. 1 will be explained by referring to FIG. 9. Within the division unit defect determining portion 64, while a difference image between the detection image f2 of the each division unit and the comparison image g2 of the each division unit being formed in a difference extracting circuit 461, a threshold value for each pixel is calculated in a threshold calculating circuit 462 for each division unit, and the difference image is compared with the threshold values in the gradation values, thereby determining to be the defect or not, in a threshold value processing unit 463.

Detailed Description Text (55):
The difference extracting circuit 461 for the each division unit obtains a difference image sub(x, y) for each division unit between the division unit detection image f2 and the division unit comparison image g2, having the position gaps 2*.delta.x0 and 2*.delta.y0 upon the calculation thereof. This difference image sub(x, y) of each division unit can be expressed by the following equation (Eq.15):

Detailed Description Text (56):
The threshold value calculating circuit 462 of each division unit calculates two threshold values thH(x, y) and thL(x, y) to determine to be the defective candidate or not, by using the position shift quantities .delta.x0 and .delta.y0 of each division unit in the sub-pixel unit, which are obtained from the position shift detector portion 442 of the sub-pixel unit. The thH(x, y) is a threshold value for restricting an upper limit of the difference image sub(x, y) obtained for each division unit, and the thL(x, y) a threshold value for restricting a lower limit of the difference image sub(x, y) obtained for each division unit. The construction of the threshold value calculating circuit 462 for each division unit is shown in FIG. 12. The contents of the calculations which are executed in the threshold value calculating circuit 462 are expressed by the following equations (Eq.16) and (Eq.17).

Detailed Description Text (57):
However, the above A(x, y) can be expressed by the following equation (Eq.18), and is a clause for compensation the threshold value depending upon the value of the difference image sub(x, y) which can be substantially obtained for each division unit by using the position shift quantities .delta.x0 and .delta.y0 in sub-pixel unit which are obtained for each division unit.

Detailed Description Text (58):
Also, the above B(x, y) can be the following equation (Eq.19), and is a clause for allowing or tolerating a minute position shift at the pattern edge (also, a minute differences in the pattern shape or in the pattern deformation can be treated as the minute position shift at the pattern edge, from a local view point), between the detection image f2 obtained for each division unit and the comparison image g2 obtained for each division unit.

Detailed Description Text (59):
Further, the above C(x, y) can be the following equation (Eq.20), and is a clause for allowing or tolerating a minute difference in the gradation value between the detection image f2 obtained for each division unit and the comparison image g2 obtained for each division unit. ##EQU3##

Detailed Description Text (66):
First, an explanation will be given on the first clause, A(x, y) in the equations (Eq.16) and (Eq.17) for calculating the threshold values for the each division, thH (x, y) and thL(x, y). Namely, the first clause, A(x, y) in the equations (Eq.16)

and (Eq.17) for calculating the threshold values thH(x, y) and thL(x, y) for the each division, is a clause for compensating the threshold value depending upon the position shift quantities .delta.x0 and .delta.y0 for the each division unit in the sub-pixel unit, which are obtained by the position shift detecting portion 442 for the each division unit in the sub-pixel unit. For example, since the dx1 which is expressed by the equation (Eq.21) indicates a local changing rate in the x direction of the gradation values of the detection image f2 for the each division unit, the dx1(x, y)*.delta.x0 for the division unit shown in the equation (Eq.18) can be said an estimation value of the gradation values of the f2 when the position is shifted by .delta.x0. Therefore, the first clause, {dx1(x, y)*.delta.x0-dx2(x, y)*(-.delta.x0)}+{dy1(x, y)*.delta.y0-dy2(x, y)*(-.delta.y0)} for the each division unit shown in the equation (Eq.18) can be said a value of change in the gradation values of the difference image between f2 and g2, which is estimated for the each pixel, when the position of f2 is shifted by .delta.x0 in the x direction and .delta.y0 in the y direction. Similarly, the second clause also can be said a value estimated but in the y direction. Namely, the {dx1(x, y)+dx2(x, y)}.delta.x0 for the each division unit is the estimated value of change in the gradation values of the difference image between f2 and g2 in the x direction, by multiplying the position shift .delta.x0 with the local changing rate, {dx1(x, y)+dx2(x, y)}, in the x direction of the difference image between the detection image f2 for the each division unit and the comparison image g2 for the each division unit, and the {dy1 (x, y)+dy2(x, y)}*.delta.y0 for the each division unit is the estimated value of change in the gradation values of the difference image between f2 and g2 in the y direction, by multiplying the position shift .delta.y0 with the local changing rate, {dy1(x, y)+dy2(x, y)}, in the y direction of the difference image between the detection image f2 for the each division unit and the comparison image g2 for the each division unit.

Detailed Description Text (68):
Next, an explanation will be given on the second clause, B(x, y) in the equations (Eq.16) and (Eq.17) for calculating the threshold values thH(x, y) and thL(x, y) for the each division unit. Namely, the second clause, B(x, y) in the equations (Eq.16) and (Eq.17) for calculating the threshold values thH(x, y) and thL(x, y) for the each division unit, is a clause for allowing or tolerating the minute position shift at the pattern edge of the each division unit (also, a minute differences in the pattern shape or in the pattern deformation can be treated as the minute position shift at the pattern edge, from a local view point). As is apparent from comparison between the equations (Eq.18) and (Eq.19) for obtaining the A(x, y) and the B(x, y), the later B(x, y) indicates an absolute value of the estimated change in the gradation values of the difference image by the position shifts .alpha. and .beta.. If the position shift can be canceled by the A(x, y), the addition of B(x, y) to A(x, y) means that the position is shifted further by .alpha. in the x direction and .beta. in the y direction from an aligned condition, by taking into the consideration the minute position shift at the pattern edge due to the minute difference on the basis the form of the pattern, as well as the deformation thereof. Namely, that for allowace or tolerance of +.alpha. in the x direction and +.beta. in the y direction, as the minute position shift at the pattern edge due to the minute difference on the basis the form of the pattern, as well as the deformation thereof for the each division unit, is the clause +B(x, y) shown in the above-mentioned equation (Eq.16). Further, as is shown in the above equation (Eq.17), the subtraction of B(x, y) from A(x, y) means that the position is shifted further by -.alpha. in the x direction and -.beta. in the y direction from the aligned condition for the each division unit. That for allowing or tolerating -.alpha. in the x direction and -.beta. in the y direction is the clause -B(x, y) shown in the above equation (Eq.17). As indicated by the equations (Eq.16) and (Eq.17), with provision of the upper limit thH(x, y) and the lower limit theL (x, y) in the threshold value for each division unit, it is possible to allow or tolerate the position shift, by .+-..alpha. and .+-..beta. for the each division unit. And, in the threshold value calculating circuit 462 for the each division unit, it is possible to control the allowable or tolerable position shift quantity

(the minute position shift at the pattern edge) due to the minute difference on the basis of shapes of the patterns and the deformation thereof for each division unit freely, by setting up the values of inputted parameters, .alpha. and .beta. at appropriate values thereof.

Detailed Description Text (69):
Next, an explanation will be given on the third clause, C(x, y) in the equations (Eq.16) and (Eq.17) for calculating the threshold values thH(x, y) and thL(x, y) for each division unit. The C(x, y) in the equations (Eq.16) and (Eq.17) for calculating the threshold values thH(x, y) and thL(x, y) for the each division unit, is the clause for allowing or tolerating the minute difference in the gradation value, between the detection image f2 for the each division unit and the comparison image g2 for the each division unit. As shown in the equation (Eq.16), the addition of the C(x, y) means that the gradation value of the comparison image g2 for the each division unit is allowed to be greater than that of the detection image f2 for the each division unit by the C(x, y), while the subtraction of the C (x, y), as indicated by the equation (Eq.17), means the gradation value of the comparison image g2 for the each division unit is allowed to be smaller than that of the detection image f2 for the each division unit by the C(x, y).

Detailed Description Text (71):
Further, it is also possible to provide a look-up table (LUT) of the C(x, y) with respect to various representative values for the gradation values in advance, so as to output the C(x, y) once the representative value of the gradation value is input thereto. The LUT is preferable in a case where it is difficult to express the way of change by means of such the function. And, in the threshold value calculating circuit 462 for each division unit, similar in the B(x, y), it is also possible to control the allowable or tolerable difference in the gradation value for each division unit freely, by the parameters .gamma. and .epsilon. to be inputted.

Detailed Description Text (76):
The threshold value processing portion 463 for each division unit decides or determines the pixel of a position (x, y) at a certain division unit to be the non-defective candidate if it satisfies the relationship of the following equation (Eq.28), while to be the defective candidate if it does not satisfy it, by using the difference image sub(x, y) obtained from the difference image extracting circuit (difference extracting circuit) 461, the threshold value thL(x, y) at the lower limit and the threshold value thH(x, y) at the upper limit for each division unit, which are obtained from the threshold value calculation circuit 462 for each division unit. The threshold value processing portion 463 for each division unit outputs a bi-valued or digitized image def(x, y) having "0" for the non-defective candidate and "1" for the defective candidate in a certain division unit.

Detailed Description Text (80):
According to the present embodiment, since the defect determination is executed after the detection image is divided into such the size that the image distortion or deformation can be neglected therefrom and compensated with the position shift for each division unit, it is possible to prevent from bringing or occurring a false or wrong report which is often caused by the image deformation. Further, since the minute position shift at the each pattern edge and/or the minute difference in the gradation values can be allowed or tolerated, it is free from the error of recognizing the normal portion as the defect. Further, by setting up the parameters .alpha., .beta., .gamma. and .epsilon. at the appropriate values thereof, it is also possible to control the allowable or tolerable quantity or amount in the change of the position shift and the gradation values with ease.

Detailed Description Text (95):
This is a function to realize a comparison inspection being similar to that executed in the image processing portion 103 on the computer. With this function, it is possible for the user to obtain an optimum value by trying to change the

inspection results, in particular, when the way of division is changed and/or adjusted with the various inspection parameters. In the case of the electron optic system, since there is no guarantee in that an equal image always can be obtained (due to influences of charge-up and/or contamination, etc.), it is impossible, without this function, to see the influence upon the inspection results which are purely brought by those inspection parameters. Further, it has another function of displaying an image, not only a final inspection result, but also an image at a middle stage, such as the image before the position shift compensation or the difference image, etc.

Detailed Description Text (97):
A first variation of the first embodiment of the pattern inspecting method and the apparatus thereof according to the present invention will be shown in FIG. 13. Although the change in gradation values due to the position shift of the sub-pixel unit is estimated for each division unit to be introduced into the threshold value in the present first embodiment shown in FIG. 9, however, in the present first variation, an image aligned in the position is produced in the position shift compensation portion 464 for each division unit, by using the position shift quantities, .delta.x0 and .delta.y0, which are obtained as the results of the position shift detection in the sub-pixel unit for each division unit, in place of estimation of the change in the gradation value.

Detailed Description Text (100):
The difference extracting circuit 466 for each division unit obtains an absolute value image diff(x, y) of the difference between the detection image f2 and the comparison image g2 for each division unit which are compensated in the position shift compensation portion 464 for each division unit. This absolute value image diff(x, y) can be expressed by the following equation (Eq.33).

Detailed Description Text (106):
First, an explanation will be given on the first clause, B(x, y) in the equation (Eq.34), for calculating the threshold value th(x, y) for each division unit. The portion, F=(maxf(x, y)-minf(x, y))/2 in the equation (Eq.35) represents the changing rate of the gradation values (i.e., change in the gradation value per one pixel) in the 3.times.3 pixels in the vicinity of the detection image f3(x, y) compensated by the position shift compensation portion 464 for each division unit, and the portion, G=(maxg(x, y)-ming(x, y))/2 represents the changing rate of the gradation value (i.e., change in the gradation value per one pixel) in the 3.times.3 pixels in the vicinity of the comparison image g3(x, y) compensated by the position shift compensation portion 464 for each division unit, therefore, the [F+G]/2 before being multiplied by "a" comes to be an average of the changing rates in the gradation values of f3(x, y) and g3(x, y). Accordingly, the B(x, y) obtained by multiplying the [F+G]/2 by "a" can be interpreted as an estimated value of change in the absolute value image diff(x, y) of the difference, which is caused by the position shift "a". Namely, the B(x, y) which can be represented by the equation (Eq.35) means, in similar to the B(x, y) represented by the equation (Eq.19), that it allows the "a" as the minute position shift at the pattern edge. And, as the .alpha. and .beta. did in the equation (Eq.19), it is possible to control the allowable or tolerable amount or quantity freely by this "a".

Detailed Description Text (107):
Next, an explanation will be given on the second clause, C(x, y) in the equation (Eq.34) for calculating the threshold value th(x, y) for each division unit. The portion, (f3(x, y)+g3(x, y))/2, though needless to say, but it is an average of the gradation values at the coordinates (x, y) of the detection image f3 and the comparison image g3, which are obtained from the position shift compensation portion 464 for each division unit. Therefore, since the C(x, y)=(f3(x, y)+g(x, y))/2).times.b+c changes depending upon the average in the gradation values of the both images, it can be said, in similar to the C(x, y) represented by the equation (Eq.20), that it is also the clause which changes the allowable or tolerable amount

or quantity in the absolute value image diff(x, y) of the difference depending upon the gradation values. Here, the C(x, y) is described as the value obtained by multiplying the representative one of the gradation values (here, the average value) by the proportion constant "b" and adding the constant "c" thereto, however, in the similar manner as is mentioned in the explanation on the equation (Eq.17), it should be substituted with a function fitting to the way of change in the gradation values if it is known in advance. Further, as the y and e did in the equation (Eq.17), it is also possible to control the allowable or tolerable amount or quantity freely by this "b" and "c".

Detailed Description Text (110):
A threshold value processing portion 467 for each division unit decides the pixels at the position (x, y) for each division unit to be the non-defective candidate if both the absolute value image diff(x, y) of the difference obtained for each division unit from the difference image extracting circuit 466 for each division unit and the threshold value th(x, y) obtained for each division unit from the threshold value calculation circuit 465 for each division unit satisfy a relationship which is represented by the following equation (Eq.41), while the pixels at the position (x, y) to be defective candidate if they do not satisfy it. The threshold value processing portion 467 for each division unit outputs the digitized image def(x, y), having "0" for the non-defective candidate pixels and "1" for the defective candidate pixels, respectively.

Detailed Description Text (112):
Further, since the minute positions shift at the each pattern edge and/or the minute difference in the gradation values can be allowed, it is also same that it is free from the error of recognizing the normal (or non-defective) portion as the defect, and it is possible to control the allowable or tolerable quantity or amount in the change of the position shift and the gradation values with ease, by setting up the parameters a, b and c at appropriate values thereof.

Detailed Description Text (114):
A second variation of the first embodiment of the pattern inspecting method and the apparatus thereof according to the present invention will be shown in FIG. 15. A difference to the first embodiment shown in FIG. 9 lies in that there is provided a gradation compensation portion 445 for compensating the gradation values of the detection image f2 and the comparison image g2 after the position alignment in the pixel unit is done in the position alignment portion 441 in the pixel unit for each division unit.

Detailed Description Text (115):
In the gradation compensation portion 445 are obtained an average value avgF of the gradation values in the detection image f2 for each division unit and a standard or reference deviation sigmaF thereof, i.e., the average value avgG of the gradation values in the comparison image g2 for each division unit and the standard deviation sigmaG thereof, and they are converted into the gradation value of the comparison image g2 for each division unit, according to the following equation (Eq.42):

Detailed Description Text (116):
Namely, according to the equation (Eq.42), the g2 is converted into an image g4 having the average value avgF and the standard deviation sigmaF. On a while, the detection image f2 is outputted as it is without any change thereto. Namely, f4(x, y)=f2(x, y). Accordingly, the f2 and the g2, each having the average value and the standard or reference deviation being different to each other, come to the images f4 and the g4 being equal to each other in the average value and the standard or reference deviation thereof through the gradation compensation portion 445. And, since the f4 and g4 are aligned in the position in the accuracy of the pixel unit inherently, it is almost equal to that the gradation values of the both are same as a whole, if the average value and the standard deviation are made equal to each other.

Detailed Description Text (118):
Basically, the present invention relates to a method for deciding the position having a great difference in the gradation values as to be the defect by comparing the detection image and the comparison image for each division unit. Therefore, it is assumed that the detection image and the comparison image for each division unit are equal to each other in the gradation values at the position other than that of the defect. However, the detection image and the comparison image for each division unit may actually differ to each other in the gradation values of the image as a whole, because of the difference such as the time of detecting the image and/or the position thereof. For instance, if the timing of detection of the image differs, the number of electrons caught by the electron detector 35 (see FIG. 1) varies depending upon the change in the condition of electrical charge in the electron optic system or the inspection object itself, therefore, the gradation values of the image as a whole might be fluctuated up and down as shown in FIG. 16(a). Further, if the position for detecting image differs on the inspection object 100, the contrast of the pattern might be different as shown in FIG. 16(b) due to the difference in the film thickness, etc. It can be said that FIG. 16(a) shows the difference in the off-set and FIG. 16(b) the difference in the gain, and either one or both (compound) of them can be compensated by the above equation (Eq.42).

Detailed Description Text (119):
In general, the bigger the difference in the gradation values as a whole, the greater the difference in the timing of detecting the images, or the greater the distance between the positions of detecting the images. Therefore, though it does not come to be a problem so much in the "cell to cell Comparison Method" mentioned previously, however, it might bring false reports often in a "die to die Comparison Method", or might cause mall- or miss-detection of the defects if loosing the inspection condition for reducing the possibility of the false reports.

Detailed Description Text (121):
In the equation (Eq.42), the distribution of the gradation values in the comparison image g2 is made equal to that of the detection image f2 for each division unit, however, the both of the detection image and the comparison image for each division unit can be also adjusted or compensated to fit to a standard or reference distribution of the gradation values by determining an average value and a reference value of the standard deviation in advance.

Detailed Description Text (125):
A third variation of the first embodiment of the pattern inspecting method and the apparatus thereof according to the present invention will be shown in FIG. 18. A difference to the first embodiment shown in FIG. 9 lies in that, not detecting the position shift in the sub-pixel unit in the position shift detection portion 442 for each division unit again after the completion of the position aligning by the pixel unit in the position aligning portion 441 by the pixel unit for each division unit, it is so constructed that the position shift amount or quantity between f1(x, y) and g(x, y) can be calculated in the accuracy being finer or lower than the pixel (i.e., sub-pixel unit), through the compensation between or among arranged elements, by using an arrangement at an alignment factor which is produced in a process or by means of obtaining the shift amount or quantity of g1(x, y) so that the alignment factor between the detection image f1(x, y) and the comparison image g1(x, y) comes to be the maximum.

Detailed Description Text (126):
In the alignment factor arrangement production portion 446 for each division unit, the alignment factor is calculated between the each image obtained by shifting the comparison image g1(x, y) for each division unit by -n through n pixels in the x and y directions respectively, and the detection image f1(x, y), thereby producing two-dimension arrangement s(p,q) as shown in FIG. 19. As the alignment factor can be used .SIGMA..SIGMA..vertline.f1-g1.vertline., .SIGMA..SIGMA.(f1-g1).sup.2, or

the correlation coefficient, etc., in the above equation (Eq.1). FIG. 19 shows the alignment factor arrangement in the case where n=4, and the alignment factor when the g1 is shifted by -2 pixels in the x direction and by 3 pixels in the y direction. The two-dimension arrangement s(p,q) produced by the alignment factor arrangement production portion 446 is outputted to the CPU 444.

Detailed Description Text (131):
The defect decision portion 46 for each division unit is same to that of the first embodiment shown in FIG. 9. Namely, in the defect decision portion 46 for each division unit, while the difference image sub between the detection image f5 and the comparison image g5 is produced in the difference extraction circuit 461 for each division unit, the threshold values thH and thL with respect to each pixel for each division unit are calculated in the threshold value calculation circuit 462 so as to decide to be the defect or not by comparing the gradation values of the difference image sub and the threshold values thH and thL for each division unit in the threshold processing portion 463 for each division unit. However, as the position shift quantity of sub-pixel unit is used the p.delta. obtained from the CPU 444 for .delta.x0, and the q.delta. obtained from the CPU 444 for .delta.y0.

Detailed Description Text (133):
Here is described a method of using only five data, i.e., s(p0-1, q0), s(p0, q0), s (p0+1, q0), s(p0, q0-1) and s(p0, q0+1) for obtaining the position shift of the sub-pixel unit, however, the more the number of data to be utilized, the nearer the values p.delta. and q.delta. should be determined to the true values thereof. Further, by using a total tendency of the two-dimensional arrangement in the alignment factor (for example, the alignment factor has only one peak value or plural ones, or it is a flat-like without fluctuation thereof, etc.), it is conceivable to give a kind of restriction on the calculation of the values p.delta. and q.delta.. In this manner, with this third variation, the arrangement of the alignment factor is produced by the hardware, while the portion for calculating the position shift by using thereof is carried out by the software in the CPU 444, therefore the calculating method can be altered easily and it has a possibility of enabling the more intelligent processing.

Detailed Description Text (140):
An advantage of using the Fourier transformation is in hat the hardware can be small-sized in the scale thereof according to an occasion. For example, in a case of obtaining the respective alignment factors for g1(x, y) by shifting it .+-.4 pixels (n=4) in the x and y directions respectively, the arrangement elements of (4.times.2+1).sup.2 =81 (see FIG. 19) must be obtained simultaneously in order to the two-dimensional arrangement of the alignment factors without time delay. Namely, it is necessary that it has the image in which the positions of 81 are shifted on the hardware. Comparing to this, in the case of using the Fourier transformation, the scale of the hardware does not depend upon the "n". If using the Fourier transformation, although the processing itself becomes complex, however it is considerably advantageous from a view point of the scale of hardware, in particular in a case that the "n" is large, i.e., when a large position shift can be expected.

Detailed Description Text (141):
Further, for obtaining the mutual correlation image being sensitive to the position shift (i.e., meaning that the mutual correlation image having a sharp peak where the positions are aligned), the Fourier transformation image can be transferred or converted into a product between Fourier amplitude image and Fourier phase image, wherein the cross power spectrum cps(s, t) is obtained by using only the Fourier phase image and is reverse-converted to obtain the mutual correlation image corr(x, y).

Detailed Description Text (144):
A fourth variation of the first embodiment of the pattern inspecting method and the

apparatus thereof according to the present invention will be shown in FIG. 21. A difference to the first embodiment shown in FIG. 9 lies in that, on the contrary to that the position shift quantity is obtained at the pitch of division unit so as to be used as the common position shift quantity (.delta.x0, .delta.y0) within division unit in the first embodiment, however in this fourth variation, the position shift quantities (.delta.x0a, .delta.y0a), (.delta.x0b, .delta.y0b), (.delta.x0c, .delta.y0c) and (.delta.x0d, .delta.y0d) obtained at the pitch of division unit are interpolated so as to obtain the position shift quantity at the pitch of the pixel.

Detailed Description Text (145):
A concept of the fourth variation will be explained by referring to FIG. 22. The black dots in FIG. 22 correspond to the position shift quantities (.delta.x0a, .delta.y0a), (.delta.x0b, .delta.y0b), (.delta.x0c, .delta.y0c) and (.delta.x0d, .delta.y0d) obtained at the pitch of the division unit. In the first embodiment, thought the position shift quantity for each division unit is assumed to be the common position shift quantity (.delta.x0, .delta.y0) in the sub-pixel unit within the division unit (thick line in the same figure), however, in this fourth variation, the position shift quantity for each pixel is obtained by tying up the black dots with a smooth curved line (shown by a broken line). If making the division unit too small, the position shift quantity cannot be determined since there is no pattern in the region, therefore, those are interpolated once obtaining the position shift quantity for each division unit having a predetermined size.

Detailed Description Text (149):
The difference extracting circuit 461 for each division unit, in the same manner as in the first embodiment, obtains the difference image sub(x, y) for each division unit between the division unit detection image f2 and the division unit comparison image g2 by the following equation (Eq.47).

Detailed Description Text (150):
The threshold value calculating circuit 462 of each division unit calculates two threshold values thH(x, y) and thL(x, y) so as to determine to be the defective candidate or not, by using the position shift quantities zureX(x, y) and zureY(x, y) of the sub-pixel unit, changing one by one for each pixel, which are obtained from the position shift detecting portion 442 of sub-pixel unit at a certain division unit. The thH(x, y) for each pixel unit is a threshold value for restricting an upper limit of the difference image sub(x, y) for each pixel unit, and the thL(x, y) for each pixel unit a threshold value for restricting a lower limit of the difference image sub(x, y) for each division unit, respectively. Those threshold values, in the same manner as in the first embodiment, contains A(x, y) for substantially compensating the position shift in the sub-pixel unit, B(x, y) for allowing or tolerating the minute position shift at the pattern edge, and C(x, y) for allowing or tolerating the minute difference in the gradation values, as shown in the following equations (Eq.48) and (Eq.49).

Detailed Description Text (153):
Also, the processing in the threshold value calculation portion 463 for each division unit is same to that of the first embodiment. Namely, by using the difference image sub(x, y) obtained from the difference image extracting circuit (difference extracting circuit) 461 for each division unit, and also the lower limit threshold value thL(x, y) and the upper limit threshold value thH(x, y) obtained from the threshold value calculating circuit 462 for each division unit, the image at the position (x, y) in a certain division unit is outputted as the digital image def(x, y), having the value "0" for the non-defective candidate if satisfying the relationship of the above equation (Eq.28), while having the value "1" for the defective candidate if not satisfying it.

Detailed Description Text (154):
Comparing this fourth variation to the first embodiment, in a case where the

position shift quantity is changed within the division unit, a difference occurs between a center portion and a peripheral portion of the division unit in performance or capacity of detecting the defect in the first embodiment. However, in this fourth variation, since the position shift quantity within the divided area or region is obtained for each pixel with approximation, the value of A(x, y), i.e., the values of thH(x, y) and thL(x, y) are changed in accordance with the above equation (Eq.50) on the basis of the obtained position shift quantities zureX (x, y) and zureY(x, y) for each pixel, thereby showing an advantage that the difference in the performance or capacity of detecting the defect within the division unit can be mitigated.

Detailed Description Text (159):
The second embodiment is also same to the first embodiment described previously, as far as the image is divided finely into such the size, so as to perform the decision on the defect for each division unit, so that said the dynamic deformation or distortion can be neglected therefrom, as is shown in FIG. 7, for dealing with the dynamic deformation due to the change in the magnetic field caused by the pattern distribution of the test object 100 and/or the vibration of the stages 131 and 132, etc. The difference to the first embodiment lies in that the image is divided into such the negligible size gradually, but not from the beginning. For convenience in explanation, the first embodiment is called as "a non-stepwise division method" while the second embodiment as "a stepwise division method".

Detailed Description Text (171):
As shown in FIG. 25, the continuous image data f0(x, y) and g0(x, y), being outputted from the image pick-up portion 102, are stored into the two-dimension image memories 48a and 48b, respectively, in a certain scanning area (corresponding to the vertical width of the large division unit). Each of the two-dimension memories 48a and 48b is constructed with the memory portion of two-dimension and the register for storing addresses for start/end of writing, in the same manner as each of the two-dimension image memories 42a and 42b. Accordingly, in each of those two-dimension memories 48a and 48b, the coordinates of the large division unit (read start/end addresses) are set from the total controller portion 104 into the registers for storing the read start/end addresses, and the detection image data f7 (x, y) and the comparison image data g7(x, y) are cut out from the two-dimension memory portions by the large division unit, so as to be read out therefrom. The position shift detecting portion 49, as shown in FIGS. 9 and 13, has the detector portion 442 comprising the statistical quantity calculation portion 443 and the sub-CPU 444, which obtains the position shift quantities .delta.x2 and .delta.y2 over the large division unit between the detection image f7(x, y) and the comparison image g7(x, y), which are cut out and read out from the image memories 48a and 48b for example, on the basis of the above equations (Eq.5) and (Eq.6) in the accuracy of the pixel unit, so as to be inputted into the position shift detector portion 51a and 51b, respectively. The above equations (Eq.5) and (Eq.6) are for the case of calculating the position shift quantity in an unit larger than the pixel, wherein .delta.x2 corresponds to mx0 and .delta.y2 to my0. In the case of calculating the position shift quantity in the sub-pixel unit, they are based upon the above equations (Eq.10) and (Eq.11). By changing the shift quantity mx in the x direction and the shift quantity my in the y direction by .+-.0, 1, 2, 3, 4 . . . n, in other words, shifting the comparison image g7(x, y) by the pixel pitches in the large division unit, then s1(mx, my)s are calculated on those occasions. And the values mx0 of mx and my0 of my are obtained, at which each of them comes to be the minimum. However, the maximum shift quantity n of the comparison image must to be a large value because of the large division unit.

Detailed Description Text (172):
Those .delta.x2 and .delta.y2 are the position shift quantities between the detection image f7(x, y) and the comparison image g7(x, y) over the large division unit, in particular, .delta.x2 is the position shift quantity over the large division unit in the x direction and .delta.y2 is the position shift quantity over

the large division unit in the y direction. During this, into the image memories 50a and 50b are written the detection image f7(x, y) and the comparison image g7(x, y) of the large division unit, which are cut out and read out from those image memories 48a and 48b. However, as the method of calculating the position shift in the position shift detector portion 49 can be applied either the method in the position shift detector portion 44 of the first embodiment, or the method in the position shift detector portion 44 of the third variation of the first embodiment, however, since there is no necessity of obtaining the position shift quantity between the large division units in the accuracy of sub-pixel unit, those stages up to obtaining the position shift in the accuracy of pixel unit are installed into this position shift detector portion.

Detailed Description Text (173):
The image memories 50a and 50b are also constructed in the same manner as the image memories 48a and 48b or the image memories 42a and 42b mentioned above. Accordingly, in each of those two-dimension memories 50a and 50b, the coordinates of the middle division unit (read start/end addresses) are set from the total controller portion 104 into the registers for storing the read start/end addresses, and the detection image data f6a(x, y) and 6b(x, y) and the comparison image data g6a(x, y) and g6b(x, y) are cut out from the two-dimension memory portions by the middle division unit so as to be read out therefrom. The position shift detecting portion 51a obtains the position shift quantities .delta.x1a and .delta.y1a between the detection image f6a(x, y) and the comparison image g6a(x, y) of the portion corresponding to the first middle division unit, which are cut out and read out from the image memories 50a and 50b, on the basis of such as the above equations (Eq.5) and (Eq.6) in the accuracy of the pixel unit, so as to be inputted into the position shift detector portion 53a and 53b, respectively. Those .delta.x1a and .delta.y1a are the position shift quantities over the first middle division unit. In synchronism with this, the position shift detector portion 51b obtains the position shift quantities .delta.x1b and .delta.y1b between the detection image f6b (x, y) and the comparison image g6b(x, y) of the portion corresponding to the second middle division unit, which are cut out and read out from the image memories 50a and 50b, on the basis of such as the above equations (Eq.5) and (Eq.6) in the accuracy of the pixel unit, so as to be inputted into the position shift detector portion 53a and 53b, respectively. Those .delta.x1a and .delta.y1a are the position shift quantities over the second middle division unit. Those .delta.x1b and .delta.x1b correspond to mx0 and .delta.y1b and .delta.y1b to my0 in each of the first and second middle division units. With changing the shift quantity mx in the x direction and the shift quantity my in the y direction by .+-.0, 1, 2, 3, 4 . . . n, respectively, in other words, shifting the comparison images g6a(x, y) and g6b(x, y) by the pixel pitches in the first and the second middle division units, then s1(mx, my)s are calculated on those occasions. And the values mx0 of mx and my0 of my are obtained, at which each of the comes to be the minimum. Namely, the maximum shift quantity n of the comparison image in the respective position shift detector portions 51a and 51b can be narrowed very much depending upon the values .delta.x2 and .delta.y2 obtained from the position shift detection portion 49 in the large division unit, thereby enabling the hardware scale and the processing time to be minimized. However, in a case where the position shift quantities can be obtained in the accuracy of the pixel unit for the large division unit, it is also possible to obtain the position shift quantities .delta.x1a and .delta.y1a and .delta.x1b and .delta.y1b in the accuracy of the sub-pixel unit too, on the basis of the above equations (Eq.10) and (Eq.11) in the respective position shift detector portions 51a and 51b. And, during the position shift detection is executed in each of the position shift detection portions 51a and 51b, into the image memories 52a, 52b and 52c and 52d are written the detection image f6a and f6b and the comparison image g6a and g6b of the middle division unit, respectively, which are cut out and read out from those image memories 50a and 50b. However, each of the position shift detector portions 51a and 51b has the construction having the position shift detector portion 442 comprising the statistical quantity calculation portion 443 and the sub-CPU therein. Namely, as

the method for calculating the position shift in the position shift detector portions 51a and 51b can be applied either the method in the position shift detector portion 44 of the first embodiment, or the method in the position shift detector portion 44 of the third variation of the first embodiment, however, since there is no necessity of obtaining the position shift quantity between the middle division units in the sub-pixel accuracy, those stages up to obtaining the position shift in the accuracy of pixel unit are installed into this position shift detector portion.

Detailed Description Text (176):
Those position shift detector portions 53a-53d have the same constructions to the position shift detector portions 44a-44d shown in FIG. 1, the defect decision portions 46a-46d to those shown in FIG. 1, and also the defect compiler portion 47a-47d to those shown in FIG. 1. However, into position shift detector portions 53a and 53b are inputted the position shift quantities .delta.x1a and .delta.y1a over the first middle division unit in the pixel accuracy, which are obtained in the position shift detector portion 51a, while into position shift detector portions 53c and 53d are inputted the position shift quantities .delta.x1b and .delta.y1b over the second middle division unit in the pixel accuracy, which are obtained in the position shift detector portion 51b. Accordingly, for the position alignment portion 441 in the pixel unit in the position shift detector portion 53a, it is enough to execute the position alignment between the detection image f1a(x, y) and the comparison image g1a(x, y) inputted for each small division unit, on the basis of the position shift quantities .delta.x1a and .delta.y1a in the pixel accuracy over the above first middle division unit inputted. Also, for the position alignment portion 441 in the pixel unit in the position shift detector portion 53b, it also is enough to execute the position alignment between the detection image f1b(x, y) and the comparison image g1b(x, y) inputted for each small division unit, on the basis of the position shift quantities .delta.x1a and .delta.y1a in the pixel accuracy over the above first middle division unit inputted. Further, for the position alignment portion 441 in the pixel unit in the position shift detector portion 53c, it is also enough to execute the position alignment between the detection image f1c(x, y) and the comparison image g1c(x, y) inputted for each small division unit, on the basis of the position shift quantities .delta.xb and .delta.y1b in the pixel accuracy over the above second middle division unit inputted. Furthermore, for the position alignment portion 441 in the pixel unit in the position shift detector portion 53d, it is also enough to execute the position alignment between the detection image f1d(x, y) and the comparison image g1d(x, y) inputted for each small division unit, on the basis of the position shift quantities .delta.x1b and .delta.y1b in the pixel accuracy over the above second middle division unit inputted. If not satisfied only by executing the position alignment on the basis of the position shift quantities .delta.x1a, .delta.y1a and .delta.x1b, .delta.y1b in the pixel accuracy over the first and the second middle division units, it is enough to obtain the position shift quantities by narrowing the investigation area or range upon the said position shift quantities .delta.x1a, .delta.y1a and .delta.x1b, .delta.yb, in the position alignment portion 441 in the pixel unit, within each of the position detection portions 53a-53d.

Detailed Description Text (188):
According to the present invention, it is possible to reduce the possibility of bringing about or occurring the erroneous or false reports due to the test objection side and the inspecting apparatus side thereof, which are caused by the discrepancies including, such as the minute difference in pattern shapes, the difference in gradation values, the distortion or deformation of the patterns, the position shift, thereby enabling the detection of the defects or the defective candidates in more details thereof.

Detailed Description Text (189):
Also, according to the present invention, it is also possible to reduce the

possibility of bringing about or occurring the erroneous or false reports due to the test objection side and the inspecting apparatus side thereof, which are caused by discrepancies including, such as the minute difference in pattern shapes, the difference in gradation values, the distortion or deformation of the patterns, the position shift, thereby enabling the detection of the defects or the defective candidates in more details thereof, in particular, in the inspection of the patterns which are formed on the object to be tested or inspected by means of the electron microscope.

CLAIMS:

1. A pattern inspecting method for inspecting defect or defective candidate of patterns on a sample, comprising following steps: an image picking-up step for picking up an image of a sample by shifting a sampling position on said sample; an image data obtaining step for obtaining a first image of said sample obtained by said image picking-up step and a second image to be compared with said first image; an image compensating step for compensating said first image and said second image; a memorizing step for memorizing said compensated first image and said compensated second image; an image dividing step for dividing said first image and said second image which are compensated and memorized, respectively, into a degree so that distortion caused on said first and second compensated images which are divided is neglectable; a position shift detecting step for detecting the position shift quantities between divided images of said first image and said second image which are divided in said image dividing step; a compensating step for compensating the position shift quantities between the divided images of said first image and said second image, which are detected in said position shift detecting step; a calculating step for calculating difference for each division unit between said first image and said second image which are compensated with the position shift quantities in said compensating step; and an extracting step for extracting the defects or the defective candidate of said sample upon the basis of the difference between said first image and said second image which are obtained in said calculating step; wherein said image dividing step and said position shift detecting step are conducted at least twice with changing of size of the division unit, where a first image dividing step divides said first and second images into first divisions and a first position shift detecting step detects first pixel position shift quantities between the divided first and second images, and a final image dividing step divides the divided image data into smaller divisions and a final position shift detecting step detects final pixel position shift quantities between the smaller divisions based on said first position shift quantities, where the final divisions are of a size where distortion in the first and second images is neglectable.

7. A pattern inspecting method for inspecting defect or defective candidate of patterns on a sample, comprising following steps: an image picking-up step for picking up an image of a sample by shifting a sampling position on said sample; an image data obtaining step for obtaining a first image of said sample obtained by said image picking-up step and a second image to be compared with said first image; an image compensating step for compensating said first image and said second image; an image dividing step for dividing said first image and said second image which are compensated and memorized, respectively, into a degree so that distortion caused on said first and second compensated images which are divided is neglectable; a position shift detecting step for detecting the position shift quantities between divided images of said compensated first image and said compensated second image which are divided in said image dividing step; a calculating step for comparing a divided image of the first image which is divided in said image dividing step with a divided image of the second image corresponding to the divided image of said first image, and for calculating difference in gradation values between the both divided images; and an extracting step for extracting the defects or the defective candidate of said sample upon basis of the position shift quantities between the divided image of said first image and the

divided image of said second image for each division unit which are detected in said position shift detecting step, and of the difference in the gradation values of the both divided images obtained in said calculating step; wherein said image dividing step and said position shift detecting step are conducted at least twice with changing of size of the division unit, where a first image dividing step divides said first and second images into first divisions and a first position shift detecting step detects first pixel position shift quantities between the divided first and second images, and a final image dividing step divides the divided image data into smaller divisions and a final position shift detecting step detects final pixel position shift quantities between the smaller divisions based on said first position shift quantities, where the final divisions are of a size where distortion in the first and second images is neglectable.

11. A pattern inspecting method for inspecting defect or defective candidate of patterns on a sample, comprising following steps: an image picking-up step for picking up an image of a sample by shifting a sampling position on said sample; an image data obtaining step for obtaining a first image of said sample obtained by said image picking-up step and a second image to be compared with said first image; an image compensating step for compensating said first image and said second image; an image dividing step for dividing said first image and said second image which are compensated and memorized, respectively, into a degree so that distortion caused on said first and second compensated images which are divided is neglectable; a comparing step for comparing a divided image of the compensated first image which is divided in said image dividing step with a divided image of the compensated second image corresponding to the divided image of said first image; and an extracting step for extracting defects or defective candidates by using a result obtained by comparison in said comparing step; wherein at least said image dividing step is conducted at least twice with changing of size of a division unit, where a first image dividing step divides said first and second images into first divisions and a first position shift detecting step detects first pixel position shift quantities between the divided first and second images, and a final image dividing step divides the divided image data into smaller divisions and a final position shift detecting step detects final pixel position shift quantities between the smaller divisions based on said first position shift quantities, where the final divisions are of a size where distortion in the first and second images is neglectable.

17. A pattern inspecting apparatus for inspecting defect or defective candidate of patterns on a sample, comprising: image picking-up means for picking up an image of a sample by shifting a sampling position on said sample; image data obtaining means for obtaining a first image of said sample obtained by said image picking-up means and a second image to be compared with said first image; image data compensating means for compensating said first image and said second image, respectively; memorizing means for memorizing said first image and said second image which are compensated by the image data compensating means; image dividing means for dividing said first image and said second image which are compensated by the image data compensating means and memorized in said memorizing means, respectively; position shift detecting means for detecting the position shift quantities between divided images of said first compensated image and said second compensated image which are divided in said image dividing means; compensating means for compensating the position shift quantities between the divided images of said first compensated image and said compensated second image, which are detected in said position shift detecting means; calculating means for calculating difference between said first image and said second image for each division unit, which are compensated with the position shift quantities in said compensating means; and extracting means for extracting defects or defective candidates of said sample upon the basis of the difference between said first image and said second image which are obtained in said calculating means; wherein said image dividing means and said position shift detecting means conduct image division and position shift detection at least twice with changing of size of the division unit, where a first image dividing step

divides said first and second images into first divisions and a first position shift detecting step detects first pixel position shift quantities between the divided first and second images, and a final image dividing step divides the divided image data into smaller divisions and a final position shift detecting step detects final pixel position shift quantities between the smaller divisions based on said first position shift quantities, where the final divisions are of a size where distortion in the first and second images is neglectable.

23. A pattern inspecting apparatus for inspecting defect or defective candidate of patterns on a sample, comprising: image picking-up means for picking up an image of a sample by shifting a sampling position on said test object; image data obtaining means for obtaining a first image of said sample obtained by said image picking-up means and a second image to be compared with said first image; image data compensating means for compensating said first image and said second image, respectively; image dividing means for dividing said first image and said second image which are memorized in said image data obtaining means, respectively, into a degree so that distortion caused on said first and second compensated images which are divided is neglectable; position shift detecting means for detecting the position shift quantities between divided images of said first image and said second image which are compensated by said image data compensating means and divided images of said first image and said second image which are divided in said image dividing means; calculating means for comparing a divided image of the first image which is divided in said image dividing means with a divided image of the second image corresponding to the divided image of said first image, and for calculating difference in gradation values between the both divided images; and extracting means for extracting the defects or the defective candidate of said sample upon basis of the position shift quantities between the divided image of said first image and the divided image of said second image for each division unit, which are detected in said position shift detecting means, and of the difference in the gradation values of the both divided images obtained in said calculating means; wherein said image dividing means and said position shift detecting means conduct image division and position shift detection at least twice with changing of size of the division unit, where a first image dividing step divides said first and second images into first divisions and a first position shift detecting step detects first pixel position shift quantities between the divided first and second images, and a final image dividing step divides the divided image data into smaller divisions and a final position shift detecting step detects final pixel position shift quantities between the smaller divisions based on said first position shift quantities, where the final divisions are of a size where distortion in the first and second images is neglectable.

27. A pattern inspecting apparatus for inspecting defect or defective candidate of patterns on a sample comprising: image picking-up means for picking up an image of a sample by shifting a sampling position on said sample; image data obtaining means for obtaining a first image of said test object obtained by said image picking-up means and a second image to be compared with said first image; image data compensating means for compensating said first image and said second image, respectively; image dividing means for dividing said first image and said second image which are compensated by said image data compensating means and memorized, respectively; comparing means for comparing a divided image of the first image which is divided in said image dividing means with a divided image of the second image corresponding to the divided image of said first image; and extracting means for extracting defects or defective candidates by using a result obtained by comparison in said comparing means; wherein at least said image dividing means conducts image division at least twice with changing of size of a division unit, where a first image dividing step divides said first and second images into first divisions and a first position shift detecting step detects first pixel position shift quantities between the divided first and second images, and a final image dividing step divides the divided image data into smaller divisions and a final position shift detecting step detects final pixel position shift quantities between

the smaller divisions based on said first position shift quantities, where the final divisions are of a size where distortion in the first and second images is neglectable.